THE HEALTH READER

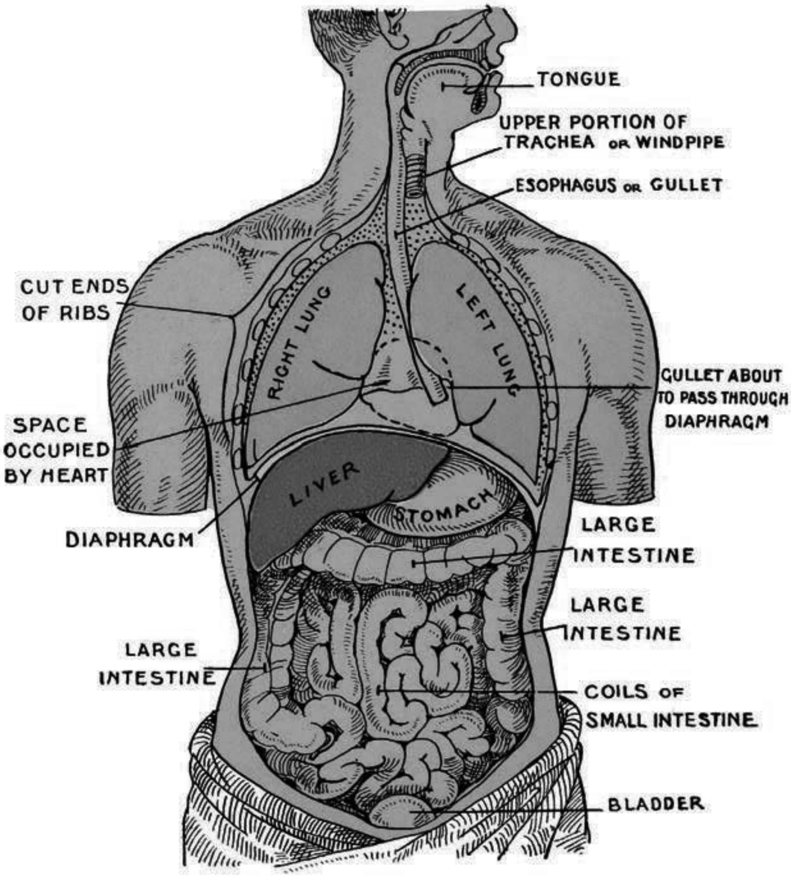

PLATE I — CHIEF PARTS OF THE HUMAN BODY

THE HEALTH READER

by

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CHAPTER I

THE HUMAN BODY

"Know thyself: that is the beginning of wisdom."

YOU will see by the title of this book that it is meant to give some account of health.

This is a subject about which we all ought to know something. Happiness and success in life depend very largely upon health but no one can take proper care of his own health, nor yet of any other person's, without understanding a little about the structure of the human body and the laws of its working. We ought to be at least as ready to learn about this, and to follow scientific methods of treating the body, as we are to adopt improvements in machinery or lighting or means of communication.

You will notice as you read that something is said about animals in this book. The reason is that a study of animals has been one of the principal means by which men of science have arrived at their present knowledge concerning the laws of life. In very many cases what is learnt about animals applies equally to us. In other cases a knowledge of animals has served to lead up to further discoveries which concern humanity alone.

You will find two or three instances in the course of the following chapters which will show you what I mean; and I hope you will find very many more for yourselves in your own later reading.

It is not wonderful that it should be so. We and they are all made of the same stuff; and life in all of us is supported by the same means.

First and foremost, we all alike depend upon the **sun**. We could none of us exist without his heat, nor without his light; nor without the water which he draws up for us from the vast surface of the sea nor yet without the winds, caused by him, which bear this water in clouds and shed it on the earth as rain. In a sense we may all well be called children of the sun and it is hardly to be wondered at that in ancient and more ignorant days the sun was worshipped as a god.

As we need sunlight for our very existence, so also we need it for our health—and that most especially when we are young and growing.

In the next place we know that living creatures are constantly taking up into themselves, from the water or from the air, the gas which we call **oxygen**. That is to say, we all **breathe**. We shall see more fully what this means in a later chapter.

Yet again, all living things take up into themselves certain other substances from outside them in the form of **food**. Their bodies have the power of changing this food first into new living substance, and then into those special and different substances of which each creature is composed. Thus the food of a plant becomes in the end wood or leaves, petals or juicy fruit; and the food of an animal becomes shell or bone, flesh, hair, or skin, as the case may be. Your food becomes the different parts of you, and mine of me.

I hope that later on many of you will learn something more of the nature of living substance. In these pages I may only tell you that in itself it is a kind of colourless jelly, to which the name of **protoplasm**, or "first stuff," has been given. It is found chiefly in the form of small roundish bodies which are called **cells**.

Cells

Now every part of every plant or animal begins by being a cell or a group of cells. Some cells are so minute that they can only be seen under microscope lenses of very high power; others may be easily examined. Cut open an orange or a lemon—choose an old one if possible—and observe the little bags in which the juice is held. These are cells. They have been much flattened by being so squeezed together, and the juice which they contain is not protoplasm, but a substance made by protoplasm still, you will be able to understand somewhat how cells are arranged by looking at them.

There are great numbers of plants and animals which consist of only a single cell. There are also plants and animals formed of cells united together, yet resembling one another, each cell doing the same work as all the rest.

Division of Labour among Cells

But the bodies of all the plants and animals we see around us are formed of great multitudes of cells, which have divided among themselves the different kinds of work necessary for the life of the plant or animal.

Thus, in a rose plant some of the cells are altered in one way to make the stem, others are altered in another to make the roots, others make the leaves, the thorns, and the flowers. Again, in a bird some of the cells make the bones, others the flesh, others the skin with its feathers—and so on, of all the parts of the body of the bird.

When a number of cells are thus grouped all together to do the same work they make what is called a **tissue**. So in plants we have leaf-tissue and woody tissue; and in animals we may have bone-tissue, muscle-tissue, and so on. We also speak of the **organs** of breathing or digestion or sense, and by an organ we understand a particular part of the body, composed perhaps of more than one kind of tissue, which does some special work that no other part can do. Thus, for example, we can only see with the eye, our organ of sight, and think with the brain, our organ of thought.

I am sure you will agree with me that there is nothing more wonderful than this division of labour among the cells, and the alterations made in them in order to fit them for their particular work.

The food of every living creature goes, of course, to increase and to renew the cells which form the different tissues of its body. In youth especially the multiplication of cells goes on with extreme activity, and by degrees makes the parts of each creature larger and stronger than they were at first, until at last a certain limit is reached. Then the creature has, as we say, done growing—has arrived at its full size and strength.

This much is true of both plants and animals. We know, however, that between these two kingdoms of life there are many and great differences and it is just in this matter of food that we find the greatest difference of all.

A plant is able to take the substances it needs as food straight from the soil, the water, and the air, and then convert them into living substance.

An animal cannot do this. Beyond taking in air and water it can only use as food substances which have already been changed from non-living into living matter: that is to say, an animal can only be fed upon plants or upon the bodies of other animals.

If you reflect a moment you will see that the animal kingdom, as a whole, depends for its food on the plant kingdom as a whole.

Perhaps you will say: All animals do not eat plants; some eat other animals. But the animals which serve as food were themselves fed on plants; thus a fox may eat a rabbit, but the rabbit feeds on the leaves of plants. So after all we get back to the plant again.

Muscle and Bone Cells

Seeing that we ourselves belong to the animal kingdom, we will now turn our attention to it more particularly.

The food of an animal is usually more difficult to obtain than that of a plant, hence the greater number of animals have to move about and hunt for it.

Now among the powers possessed by living substance is the power of drawing together, or contracting, and then of spreading out again, or expanding.

In the division of labour of which I told you it often happens that some cells give up this power, it being unnecessary for the particular part they have to play. But in the bodies of animals we find that great numbers of cells devote themselves entirely to developing it. They form masses of tissue whose one business in the body is to contract and expand, and it is by means of these movements that the body of the animal, as a whole, is enabled to move.

Such masses of tissue are, as you, know, called **muscle**. In some lowly animals, muscular tissue is the hardest part of the body, and gives it both its shape and its power of movement, as you may see in an earthworm. In the higher animals we find the cells building up a harder tissue, to which the muscles are then attached. This gives the whole body much greater firmness.

In some animals the hard tissue forms the outer covering and protection of the body, as in insects, crabs,

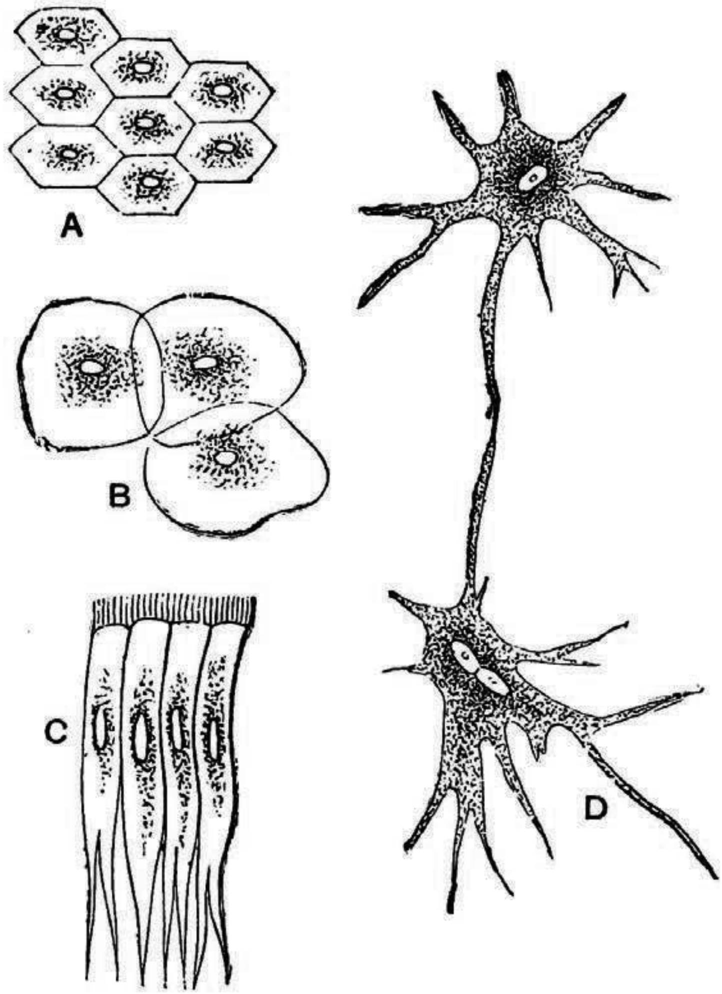

FIGURE 1 — DIFFERENT KINDS OF CELLS

A, cells from the mucous membrane; B, cells from the lining of the mouth; C, ciliated (hair-like) cells from wind pipe; D, nerve cells.

and lobsters. In the highest animals, the vertebrates or backboned animals, to which we ourselves belong, the hard tissue, called **bone**, is inside, and forms a framework and support to the body.

The muscles and bones of animals are often, as you know, wonderfully strong, and capable of very swift movement. I need not remind you of any instances of this.

Nerve Cells

But you will readily understand that it would be of little use for an animal to be able to move swiftly if it had no means of perceiving where its food was, and of choosing in which direction to move.

And so we find that in all but the very lowliest animals certain cells have taken upon themselves the work of attending to the world outside, and governing the movements of the animal accordingly.

Such cells are scattered over the surface of the body in the lowlier animals, and they correspond to what, in ourselves, is the sense of touch. But as we advance to the higher animals we find these cells beginning a division of labour among themselves. Some, grouping themselves in one place, give the animal what we call the sense of smell; others in the same way bring about the sense of taste; others, again, grouped together in a certain position, bring about the senses of sight and hearing. Besides all these there are many which are stationed, as it were, in the muscles of the animal's body, and start and direct their movements. All these cells are called **nerve-cells**. The most important nerve-cells are those which, in the fore-part, or head, of the bodies of the higher animals, form a mass called the **brain**. The brain is the centre of government for the whole body. It receives messages from the nerves of the senses, and sends orders to the nerves in the muscles, along strands of tissue formed by the nerve-cells for this purpose.

Of all the wonders of protoplasm none is greater than the wonder of the brain and nervous system of animals.

I can only mention it briefly here, just in order to show you in outline how the movements of animals are directed; we shall learn a little more about it later on.

Food-pipe and Blood-vessels

Besides these tissues of muscle and bone and nerve, we find, in all but the very lowliest animals, that some of the cells have formed themselves into a kind of food-bag or food-pipe; into this the food is sent to be made liquid and ready to nourish the tissues.

We also find channels or pipes formed by the cells, by which the liquid food is conveyed round and round the body, so that every part may be supplied.

In a great number of animals the muscular tissue forms a little pump in one part of the channel, and pushes along the liquid which bears the food, We call this pump the **heart**, and in the higher animals the liquid containing the food is known as **blood**.

The Build of the Body

Although it is perfectly true that all living things, and more especially all animals, are our relations, yet, as you may have supposed, some are much nearer relations than others. Of the two great divisions of the animal world—the backboneless or **invertebrates**, and the backboned or **vertebrates**—we belong to the latter and among these again we belong, of course, to the **air-breathers**.

You will find it very interesting to make a list of all the vertebrate animals you know, and then try to sort them out according to the resemblances you notice between them, and guess which are most nearly related to which. The more you are able to study their different shapes and the build of their bodies, the more plainly you will see that they are all made, as it were, upon one great general plan, which has been altered in details to suit different needs, but in essentials remains the same. Here, however, we have only space to consider what is the build of our own body.

We have, as you know, a head, a trunk, and two pairs of limbs. These are supported and held together by a bony framework or **skeleton** within us. In this we may notice first of all the **backbone** or **vertebral column** (Figure 2), from which the vertebrates receive their name. It is composed of a number of small bones, or **vertebræ**, of a peculiar form, so held together, one upon the other, as to form a column. These vertebræ are separated from one another by discs of gristle

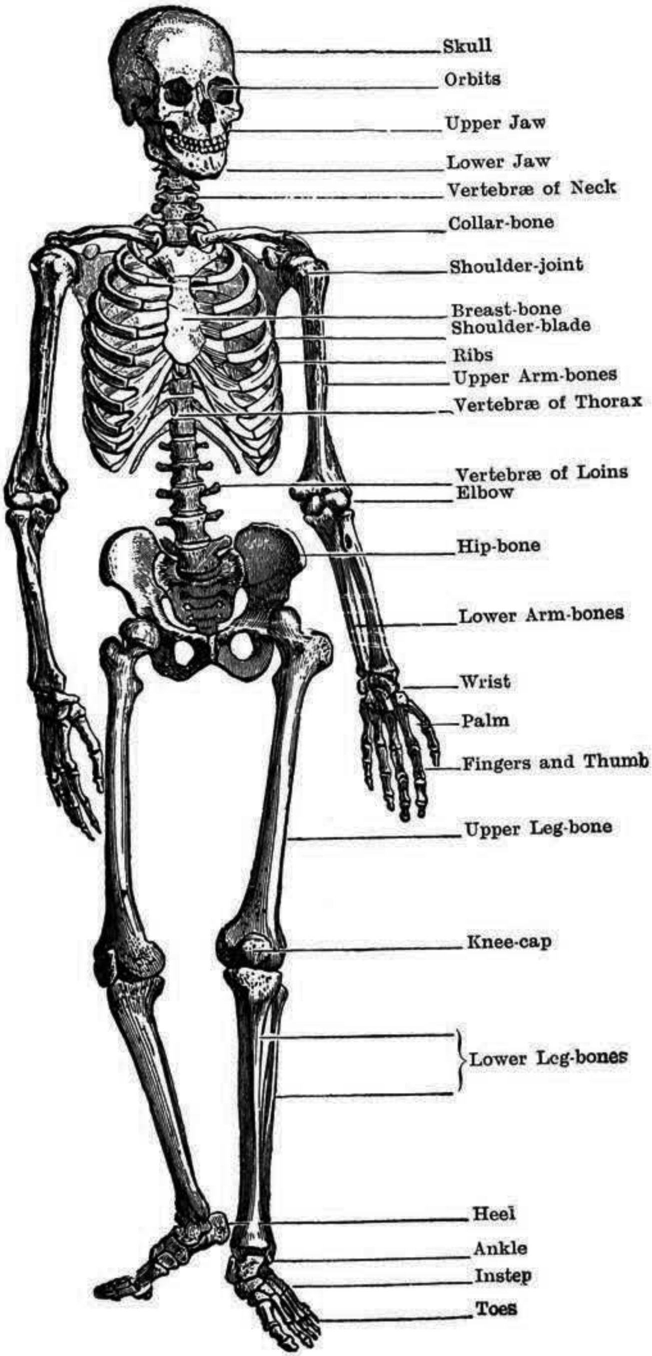

FIGURE 2 — THE HUMAN SKELETON

or **cartilage**, which serve as buffers, and render the column to a certain extent flexible.

On the top of the backbone we have the **skull**, where a number of bones are so arranged together as to form a great case, within which is lodged the brain. At the upper and the lower end of the backbone we have a bony girdle: above, the **collar-bones**, and **shoulder-blades** supporting the **arms**; below, the **hip-bones**, which connect the **legs** with the backbone.

Below the neck, on either side of the backbone, we have long extensions of bone, bent forward, and joined at their front ends by cartilage (the so-called **breast-bone**), thus forming a sort of cage in front of the backbone. These, as you know, are the **ribs**, which form the **chest** or **thorax**. Below the chest the trunk has no bony protection save for the backbone itself and for the hip-bones, which latter are larger and stronger in us than in many of our brother animals. This is because, owing to our erect posture, extra strength is needed to support the weight thrown upon them. The lower part of the trunk is called the **abdomen**.

Within the skull, as we said just now, we have the brain, the great ruling centre of the nervous system. Second only in importance to the brain is the **spinal cord**, consisting of nerve fibres which go right down the backbone within a hollow channel formed by openings in the vertebrae. Thus we see that the two most important parts of our bony framework, the skull and the backbone, serve to protect the two most important parts of the nervous system, the brain and the spinal cord.

In the head we have the eyes, ears, nose, and mouth, that is to say the principal **sense-organs**. There also is the upper opening of the **food-pipe**.

In the chest we have the **heart**, the **lungs**, and upper portion of the **food-pipe**.

In the abdomen we have chiefly the **food-pipe**, and the organs which assist it in its work. With these are also other organs, whose business is to help in getting rid of waste matters from the body.

This framework and these organs, when they are full-grown and well nourished, may be of great size, strength, and activity, as we know. What we do not know so well, or perhaps do not always remember, is that they are for the most part slow in reaching their full growth, and during the growing time are not as strong as they will be by and by. Things that happen to them during that time will affect them more, whether for weal or for woe, than things that happen later on. Therefore it is during our youth that a reasonable care will do most good, and unfortunate mistakes work most harm.

While we are still quite little we have to be entirely cared for by older people but as we grow old enough to think and reason we begin to take the care of our own bodies more and more into our own hands. And therefore, let me repeat, it is very necessary that we should learn something about our own structure as soon as we can properly understand it, so that we may be saved from making mistakes which perhaps cannot be repaired when we are fully grown up.

CHAPTER II

THE FOOD-PIPE

"There are some of our natural desires which only remain . . . as means of the higher powers acting."

— Coleridge

We have now learnt a little about the substance of which plants and animals are made. We have seen, among other things, that in order to live and grow, plants and animals must constantly take into themselves matter from outside.

The matter we take in is, of course, our food and, as we know very well, we put our food into our mouths, and swallow it down into a food-pipe, which runs right through our bodies, and has an opening at the lower end.

The food-pipe of a man is of what we may consider a moderate length, neither so short as that of the flesh-eating or carnivorous, nor so long as that of the herb-eating or herbivorous animal. Yet perhaps, after all, you will find it longer than you had supposed when I tell you that its length, in a man of average height, is about 26 feet. The greater part of it is arranged in a closely-packed coil which lies in the abdomen.

You will naturally ask why it is necessary that the food-pipe should be so long as this. It is necessary partly because each different sort of food has to be broken up and dissolved in a different part of the pipe, and in rather a different manner and partly because, as you will see, the longer the pipe, the more certainly every bit of good that is in the food will be got out of it and passed into the body.

For you must be careful to remember that the food which is in the food-pipe is not yet in the body: the pipe in itself is nothing but a passage down which substances from outside may be sent.

How the Food-pipe is Made

Let us now consider how this pipe or tube is made. It is composed of muscle, and is lined with a coating of what appears to be an exceedingly delicate and soft skin, which, when examined closely, is seen to consist of a layer of cells that make within themselves a rather thick slimy substance. This substance the cells pour out upon the surface of the food-pipe, and thus keep it smooth and slippery. The word **membrane** is used as the name for a very thin skin; and on account of the slime or **mucus** this membrane is called the **mucous membrane**. The mucous membrane of the food-pipe begins at the mouth and goes the whole way down to the end.

Throughout all the food-pipe run an immense number of tiny blood-vessels, finer than hairs. You cannot see them except by means of a very strong lens, but every part of the food-pipe, and more especially its inner coating, is quite thickly covered with the network they make.

When we examine the food-pipe of some lowly animals, such, for instance, as a worm, we find that the tube is straight, and also that throughout it is of the same width, more or less. But when we come to the higher animals we find that this is not so. Not only is the food-pipe coiled, as we saw above, but we find it stretched out in more than one place so as to form a kind of pocket or bag. This is made possible by the fact that the food-pipe is exceedingly elastic, stretching and contracting very easily. It has been stretched to form a kind of bag in those places in which it is necessary for the food to remain for some time, namely, the mouth, where the food stays for a minute or two, and the stomach, where it stays for three or four hours, and sometimes even much longer. Though it does not form a pouch again the pipe becomes very much bigger round towards the end. By the time the food gets as far as this it has had nearly everything that is useful extracted from it, so that the last part of the food-pipe, while it takes up whatever good is left, is also to some extent a place in which the rubbish is collected until the moment comes for casting it out.

If you will now look attentively at the accompanying diagram (Figure 3) you will see how the food-pipe is arranged. You must not suppose that within the body it looks exactly like this, for a diagram is not so much

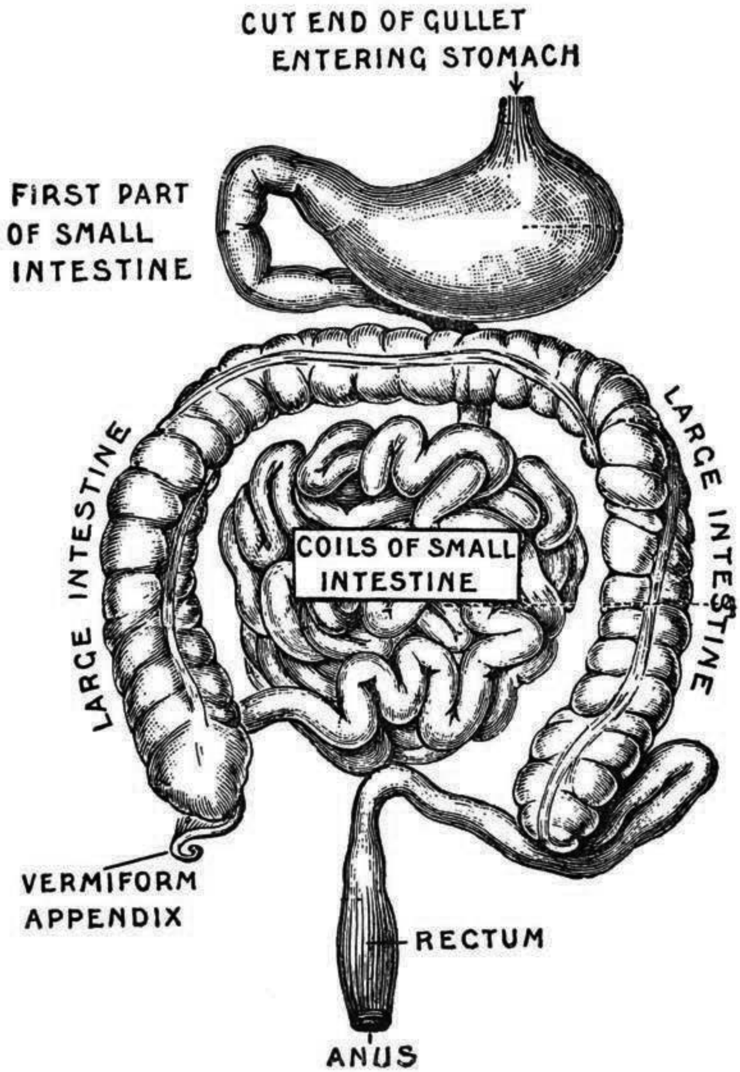

FIGURE 3 — DIAGRAM OF FOOD-PIPE

a picture as a map, designed principally to show the position of different parts with regard to other parts.

You will naturally ask how all this long pipe is kept in place. It would take too long to tell you in detail, but you may remember that it is suspended, chiefly from the region of the back, in folds of membrane. This membrane is exceedingly thin and yet most marvelously strong.

Different Kinds of Foods

We must now consider for a moment the foods we commonly use. Various as their taste is to our sense, and different as they are in appearance, these foods have been found to consist of five kinds of substance. They are:—

1. **Water**—which forms a part (and usually a very large part) of every food-stuff.

2. **Proteins** (meaning "first " or "most important") —which we might perhaps also call **curds**, after the familiar curd of milk, which is protein. These contain **all** the principal substances of which protoplasm is composed. Lean of meat, eggs, and fish are the forms of food which contain most protein but it is present also in milk, bread, peas, lentils, and several other things.

We should remember that water and proteins are absolutely essential to life.

3. **Fats**—substances which burn readily and give us heat, but contain only a part of the material of living substance, or protoplasm. (Examples: butter, milk, fat of meat, bacon.)

4. **Starches and Sugars**—which also burn readily and also contain only certain parts of the material of protoplasm. These are furnished chiefly by our vegetable food.

5. **Mineral matters** or **salts**.

In the chapter on Food you will find a fuller account of these substances; I will only mention here that they are often found together in what may appear to us to be all one kind of substance. Thus milk, besides a very large proportion of water, contains fat, protein, sugar, and salts. The fat collects on the top of standing milk, forming what we call cream.

Proteins, starches, sugars, and fats are nourishing food-stuffs; but, besides the foods which contain them in abundance, it is necessary to eat fruit and green vegetables, which are nearly all water and give us very little actual nourishment. These are wholesome: firstly, because of the water in them; secondly, because they have within them certain salts, dissolved out of the earth by the plants, which are of great service in keeping our bodies healthy; and, lastly, because, as you will see, they are an immense help to the food-pipe in the work it has to do.

In considering food-stuffs you must remember that some proportion of most of them, as we commonly see them and use them, is neither protein, nor fat, nor starch, properly speaking, but is a sort of wrapping in which these substances are stored—such, for instance, as the cell-walls in plants.

Digestion in the Mouth

And now let us take a mouthful of food and see how it is broken up, or **digested**, and how the nourishment in it is absorbed during its progress through the food-pipe.

We will take, as we often do, a piece of bread and a piece of meat together. Our piece of meat has a little fat upon it and thus the mouthful contains something of each of the three chief solid sorts of food-stuff: protein, fat, and starch.

We put the mouthful, then, into the mouth; and here we tear it and crush it with our teeth, and turn it and press it with the tongue.

In the course of our lives we have, as you know, two sets of teeth—the temporary or "milk-teeth," twenty in number, and the permanent teeth, thirty-two in number. The permanent teeth are of three kinds: in each jaw the four **incisors**, or cutters, in front; the two **canines** (from **canis**, a dog, because the dog has them so well developed), which are tearers, and are placed one on each side of the incisors; and the **molars**, or grinders, of which there are five on each side.

As we bite we feel a watery juice coming into our mouths, mingling with the food and making it all loose and soft, so that it is easy to swallow.

Whence does this "water" come? If you look at the diagram on page 22 you will see what look like three little pouches, which open into the mouth. These are not really pouches; each one consists of an innumerable host of tiny gland-cells, all crowded together, making a rather soft but solid lump.

Gland-cells and Glands

Now I must tell you that in their division of labour certain cells have taken upon themselves a most wonderful and important work—that of the making of juices. As fast as they draw in food and make it into protoplasm, so fast do they turn the protoplasm into a particular kind of juice. All do not make the same juice; and it usually happens that those which do make the same are clustered together, forming a mass which is called a **gland**, while the cells themselves are known as **gland-cells**. The business of making juice is called **secreting**; and the juices are often spoken of as **secretions**.

Ferments

Some of the juices secreted by glands contain a very marvellous substance called a **ferment**.

There are a number of ferments known to men of science, and they all have the power of producing some kind of change in particular substances when they are brought into contact with them. Some of these ferments are found, both in plants and in animals. We ourselves have ferments in our bodies. But as yet ferments are only known by what they **do**, some acting on one substance, some on another; no one yet knows exactly what they **are**.

The Salivary Glands

Well, the little pouches by the mouth are glands — called the **salivary glands**. Opening into the mouth by little pipes or **ducts**, they pour into it their juice, which is called **saliva**, and has a ferment in it. This ferment has no effect on the lean meat or the fat, which are not changed in the mouth except by being simply reduced to tiny pieces; but it has a great influence on the bread. The bread, as you know, is chiefly starch. Now starch is very difficult to make liquid—or to **dissolve**, as it is called. Without being dissolved it cannot be taken into the body. Hence it must first of all be somewhat altered; and it is the ferment in the saliva which brings about the necessary alteration. Wonderful to relate, it turns the starch into **sugar**. Sugar is a substance very closely related to starch, and, as you know, is quite easy to

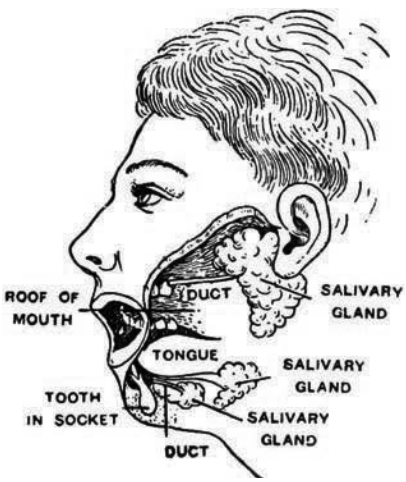

FIGURE 4 — THE SALIVARY GLANDS

dissolve. If you take a piece of stale bread by itself into your mouth, and bite it thoroughly, so that the saliva is well mixed up with it, you will detect the change that has taken place by finding that the bread tastes sweet.

This brings us to the reason why we should bite all our starchy foods well. We bite our meat in order to reduce it to small pieces; but we bite our bread, and our rice and potato, in order to mix the saliva in our mouths with the starch, and render it **soluble**—that is, easy to dissolve.

You will remember we found that the whole of the delicate skin of the food-pipe was lined with exceedingly small and fine blood-vessels. These are for ever taking up everything they can through their thin walls. As fast as food is dissolved it is thus passed into the blood. So when we have bitten up our mouthful of bread and meat, some of the starch of the bread, turned into sugar and quickly dissolved, has already passed into the blood by the tiny blood-vessels in the mouth.

The Gullet

All the rest of the food, the lean meat, the fat, and so much of the starch as has not yet been converted into sugar, is now rolled back over the tongue towards the throat. Then, by a push from the tongue and the muscles of the throat, it is sent down the straight part of the food-pipe called the **gullet**, or **esophagus**. After the food has passed down the throat we are not, in an ordinary way, aware of its passage through our body until it is near the end of the journey.

But you must not suppose that it just slips down, as water runs through a pipe. The walls of the gullet are made of muscle. This muscle contracts around and behind the food as it goes down, and so forces it on its way. Get a length of india-rubber tubing, and slip into the end of it a ball, about the same size round as the interior of the pipe. If you give a squeeze to the top part of the tubing, so as to force the ball down a little way, and go on squeezing thus, hand under hand, just over and behind the ball, till it comes out at the other end of your bit of pipe, you will get a rough idea of the way in which the muscles of the gullet act in pushing the food downwards into the stomach. If we swallow large, unwieldy pieces of food, we give the gullet hard work to get them down.

Digestion in the Stomach

Well, when our mouthful has passed the gullet and arrived at the stomach, it finds itself, as you may see by Figure 5 (p. 25), in a good-sized bag. This bag is lined with glands set closely side by side and opening into it. They secrete a juice called the **stomach**, or **gastric**, **juice**, which contains a ferment. Immediately on the arrival of the food, these glands begin pouring out their juice upon it. Now the ferment of the gastric juice has the particular power of dissolving proteins, so that it is here that the meat is digested. But the stomach is not only the place where proteins are dissolved, it is also the place where food of all sorts is churned until it is reduced to a kind of thick yellowish-grey cream, which is termed **chyme**.

This churning is done by the muscles of the wall of the stomach. I could not attempt to describe them to you here, but you should know that there are hardly any muscles in our whole body more wonderful than these. All the time the food is in the stomach, they are contracting and expanding—contracting and expanding —and thus hurling the food from one part of the stomach to another. This is fairly hard work, and you will readily understand that we make it much harder, and greatly fatigue the stomach, by sending down into it unsuitable or ill-bitten food.

The stomach goes on churning until the whole of the food is turned into **chyme**; there must not be any lumpy bits left. For if you look at Figure 5 again, you will see, marked at the lower end of the stomach, the

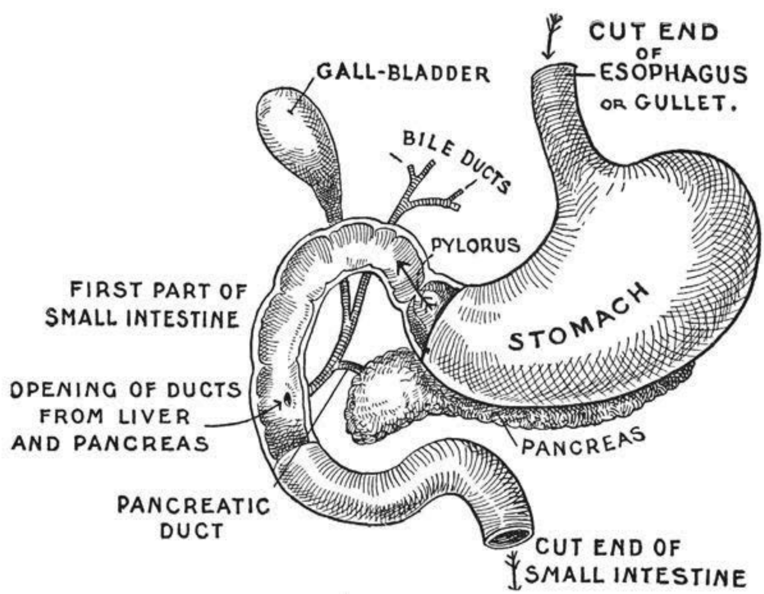

FIGURE 5 — DIAGRAM SHOWING HOW THE JUICES OF THE LIVER AND PANCREAS ENTER THE INTESTINE

pylorus. Pylorus is a Greek word, and means "Keeper of the gate," and this name has been given to a strong ring of muscle which the food has to pass through before it can get out of the stomach into the first part of the small intestine. This keeper of the gate will let nothing big or rough go past him; he allows only a narrow opening, just enough for a small stream of thickish liquid to slip through. It is true that sometimes little hard things, such as pips and fruit-stones, manage to creep past, but this is an exceptional event, and only made possible by all the rest of the food being rendered so smooth and creamy that it helps them to glide through along with itself.

So that after our bread and meat have been for some time in the stomach—(it will take about three and a-half hours to digest them)—we should be very much puzzled to find them again.

What has happened? The proteins, or curdy part, of the lean meat, and the small quantity of protein which was in the bread, have been to a great extent dissolved out by the ferment in the gastric juice; the tiny blood-vessels of the stomach have absorbed all that has been dissolved, and it has now become a part of the blood itself. Only the wrappings which once held them are left in the stomach, crushed and torn up into shreds, not visible in the general mass of the liquid pulp. So much for the proteins.

The fat is still there, though we cannot distinguish it with our eyes; and so is the starch of the bread—so much of it as was not dissolved out in the mouth.

Action of Juices of the Liver, Pancreas, and Intestine

And now the chyme, being ready at last, slips through the pylorus, and, pushed on by the contracting muscles, finds itself in the small intestine.

If you look once more at Figure 5 you will see that it has arrived at the mouth of two ducts opening together into the small intestine from two bodies, which are drawn one on either side of the pipe.

These, again, as you may have guessed, are glands. The first, the largest gland in the body, is the **liver** (*see* the frontispiece), which lies for the most part at the back of the food-pipe, somewhat to the right. The juice which it secretes is called **bile** or **gall**; it does not contain a ferment. The liver is constantly at work making bile, and stores it ready for use in a little bag which you see marked on Figure 5 as the **gall-bladder**.

The second gland is the **pancreas** (*see* Figure 5 again). The juice from this gland is called the **pancreatic juice**. It contains three very powerful ferments.

No sooner has the food touched the mouth of the ducts than these two glands pour out their juices into it. A very important work of the bile is its action upon the fats in the food. Containing no ferment, it does not dissolve them, but it divides up the minute particles of fat into particles still more minute. In this it is assisted by the pancreatic juice, which, however, does a great deal besides. Helped by a ferment in the juices secreted by the intestine, it mingles with all the starchy food which has not been dissolved by the saliva in the mouth, and dissolves it. It also mingles with any proteins that may possibly have escaped the gastric juice in the stomach, and dissolves them too. In fact, the ferments in the pancreatic and intestinal juices are the most powerful of all the ferments in the food-pipe, and finish up the main part of digestion. After the bile and these juices have acted upon the food, it becomes more liquid and milky in appearance, and is then called **chyle**.

Meanwhile the food is being forced steadily onward along the small intestine. There must be no stopping anywhere, for as fast as the ferments work the food that is done with must be moved out of the way to make room for more.

What the Villi Do

Now, if you could see a piece of the inner coating of the small intestine, you would notice that it is more velvety in its appearance than the rest of the lining of the food-pipe; and if you examined it under the microscope, you would see that this velvety appearance is caused by an immense number of exceedingly minute projections. They cover the whole of the small intestine, more especially towards the upper end; and there are about five millions of them in all. These are called **villi**—from a Latin word **villus**, meaning a **tuft**—because they make the surface of the small intestine look rather shaggy compared with the rest of the food-pipe.

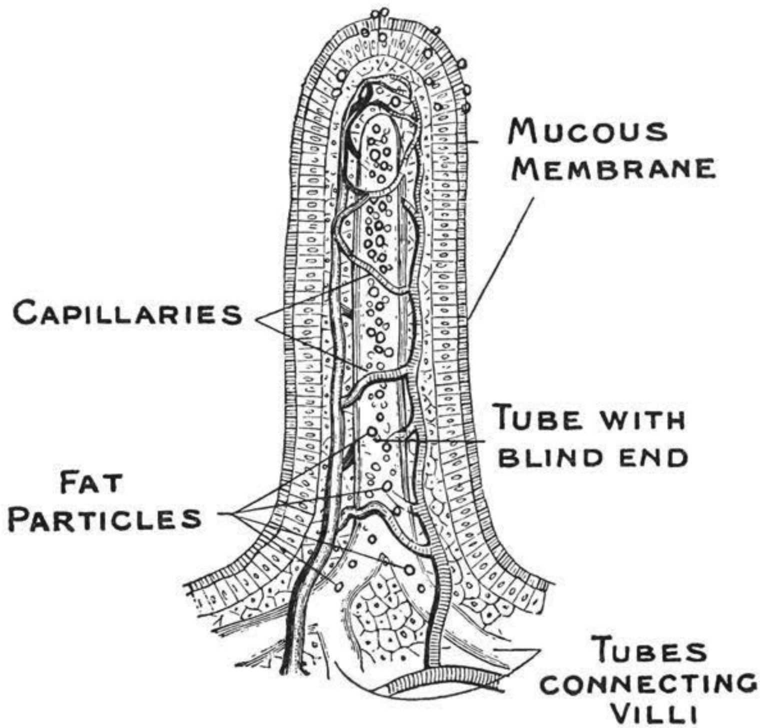

FIGURE 6 — A VILLUS, HIGHLY MAGNIFIED

A very good way to make yourself understand the difference between a gland in the intestine and a villus is to take a glove and draw it on to your hand, then turn it inside out, and draw your hand away, so that the fingers are left looking like holes with a pocket in each. These represent the glands opening into the intestine. Now turn your glove back ready for putting on again; the fingers will then represent the villi, as they hang with their blind or closed ends into the food-pipe. Only you will not forget that the villi and the glands are very, very small.

Each villus has inside it a cage-like network of the most minute blood-vessels, within which again is a little tube with a blind end. The millions of these little tubes, joining together at the bases of the villi, are connected up to make a set of larger tubes and these, gradually passing up into the chest, form at last a pipe, about the size of a goose-quill, which empties itself into a large vein near the heart.

When the chyle is travelling over the villi they suck up from it all the fatty part. Having drawn this into the little tube within them, they contract, and pump it into the series of tubes just mentioned. By these, in time, it reaches the pipe we mentioned in the chest, and is poured in one stream into the heart. Thus the fats enter the blood in a more roundabout way than do the other forms of food.

Now look once more at Figure 3 (page 17), and observe the length and the many coils of the small intestine. In such a length of food-pipe, with tiny blood-vessels all over every part of it, eager to absorb into the blood whatever food has been dissolved by the processes of digestion, it is clear that but little of what is useful to the body can be lost.

But as the food passes on in this way, parting with its substance to the blood, it must necessarily diminish in bulk; and the more nourishment there is in it, the more it will thus be reduced. At first sight this might seem to be an advantage, but if we look closer at the matter, we shall see that the food being so much less in bulk makes a difficulty for the food-pipe. The food can only move by means of that continual contraction of the muscle which we illustrated with the india-rubber pipe a little while ago. It is more difficult to force the food along the coils of the intestine, which have so many turnings and twistings, and lie more or less horizontally, than it is to force it down a straight vertical tube like the gullet. And the difficulty is much greater if the mass to be pushed along is a small one; for then the muscles have nothing to close over, nothing to give a good squeeze to; they can only more or less press upon themselves. It is here that such food-stuffs as fruit and vegetables are very useful. They contain but little nourishment, and none of the juices or ferments of the food-pipe can dissolve much out of them except water and the salts I told you of. They are thus sent along practically unchanged, forming a mass for the muscles to push upon, and making easier the general movement of the food. It is of the utmost importance that, the food in the intestine should be kept steadily though slowly, moving; a stoppage in its movement may indeed become actually dangerous to life; hence we see that it is important to eat a certain amount of fruit or green vegetables with our food.

Food in the Large Intestine

When the food has passed from the small into the large intestine it has become nearly all solid—for as fast as that part of it which is useful to the body was dissolved out of it, the tiny blood-vessels absorbed it into the blood. Now only shreds and remains of useless matter are left.

If you look at Figure 3 again, you will see that the place where the small intestine widens into the large intestine makes rather a sharp corner, and that a little finger-like projection is drawn coming down from that part. This little projection is called the **vermiform** (or wormlike) **appendix**; and it has an opening into the intestine. It is important to notice it, because sometimes pips, or fruitstones, or bits of nuts, which have not been digested, lodge in this opening as they pass by it, or get right into the vermiform appendix, and cause it to become inflamed. This inflammation is a serious illness, which you may have heard spoken of as "appendicitis." It may, indeed, be due to other causes besides the one mentioned here still, we should remember that it is unwise to swallow fruitstones and pips.

In the Rectum

From the larger intestine the food passes into the **rectum** (Figure 3); and, when it is there, we once more become aware of it: we are warned, as it were, that there is rubbish waiting to be cast out of us for if it stays with us any longer it will do us harm.

The rubbish is then cast out through the **anus**, the opening at the lower end of the food-pipe and so we come to the end of the journey of the food through our bodies, and of the history of its transformation by the way.

How it is all Done

And now I think there must be many thoughtful readers who have been wondering how this is all accomplished. What makes the muscles contract? What makes the glands secrete? What causes the juices from the glands to gush forth? How, too, is our tongue able to taste? and how is that message conveyed to us which tells us to cast out the rubbish from the food-pipe?

Both the movements which we are aware of, and the movements we are not aware of, are set up and governed by the brain and nervous system. Nerve-threads run to the brain from every part of the food-pipe, and back again to every part of it from the brain. When food is placed in our mouths, the first set of nerves convey the news to the brain, and instantly, along the second set, is sped the command to bite it and prepare to swallow it. Every movement made, as well as the pouring out of the saliva and the tasting of the tongue—all is caused and controlled by the action of the brain and nerves.

But you will ask me how it is that we know what is happening in the mouth, and to some extent what is happening in the rectum, but do not know what is going on in the rest of the food-pipe.

That is because, as we shall see more fully in another place, there are two great divisions of the brain; one of these is, as it were, the home of all our knowledge and of our will, and we are aware of the messages which it receives, and of the movements which it causes. But the other part of the brain works for us without our being aware of what it does. The nerves of the mouth, and some of the nerves of the rectum, run up to the first division of the brain; and so we know what is happening in these two parts of the food-pipe, and we have power over them. But the nerves from the rest of the food-pipe go to the other part of the brain, and thus all the long and manifold work of digesting our food is performed without our consciousness.

Is not this a very wonderful thing?—and also of very great advantage to us? Think what it would be if we were obliged, as the saying is, to give our minds to digesting our food. It would take up so much of our attention that we should have none left for anything else. Now we eat our meals, and get up from the table, and go off to our work or our play and while we are busy with these, and have quite forgotten our food in the food-pipe, it is being digested for us, absorbed into our blood, and built up into our bodies, without our having any trouble about it.

Yet we must never forget that if it were not for the brain and the nerves this work of the food-pipe could not be done.

Importance of Taking Care of the Body

Now, all wise men and women are diligent about taking care of the body for if people do not take care of their bodies they become weak and sickly, and perhaps downright ill.

From what you have now learnt of the food-pipe I am sure you can see what an important part of the body it is, and therefore how important it is to treat it well.

Let us go shortly through the main things to be remembered in our care of it.

Care of the Teeth

In the first place, as we have already seen, we ought not to swallow our food in big lumps; and, to avoid this we must make good use of our teeth. We must bite our food up small, and not forget that bread and other starchy foods are to be partly digested in the mouth by mixing them well with saliva. Now, this is a matter of habit. Every sensible boy and girl will take pains to get into the habit of biting food thoroughly, knowing well what is the harm done by "bolting" it.

But to bite well we must have good teeth and in order to have good teeth we must spend some trouble upon them. You know that the surface of our teeth is covered with a whitish substance called **enamel**. This enamel is exceedingly hard—in fact, it is the hardest part of the tooth. Within it is a layer of bone-like matter called **dentine**, considerably softer than the enamel and within the dentine, again, is a cavity or hole, in which is a still softer **pulp**. If the enamel is worn away the softer parts of the tooth must be exposed and on being exposed they decay. Once gone, the enamel can never be replaced so do not damage it by cracking nuts.

What is it that may destroy the enamel of our teeth and cause the dentine to decay? I must tell you more fully about this later on; here I will only say that any substance from the food we eat, when left upon the teeth, begins to decay and this decay attacks the enamel too, and, as we say, eats it away. It is especially bad for the teeth to have little bits of food sticking between them.

To prevent the destruction of the enamel we must keep our teeth clean. We should brush them thoroughly with fresh water and a little tooth-powder, at least twice a day, on getting up in the morning and going to bed at night. We must be careful about the choice of a tooth-powder, for many of the pastes and powders advertised are very injurious to the enamel; in fact, it is better to use nothing but water and the tooth-brush than to use them. A good powder which will help cleanse the teeth and do no harm to the enamel is camphorated or plain powdered chalk. After applying the chalk a little common yellow soap may be used. The chalk can be obtained from ground oyster shells.

Some people will tell you that the milk-teeth of children need not be brushed; but this is a very serious mistake. For if the milk-teeth decay, they infect the permanent teeth which lie close beside them in the gums waiting to come through and the permanent teeth, once injured in this way, can never be cured.

When brushing one's teeth it is a good thing, at the same time, to rinse the mouth out and gargle the throat. For this last purpose, you should dissolve in water two or three crystals of "permanganate of potash." For one penny you can buy enough of it to last you six months and it will cleanse the mouth and throat very effectually. People do not always pay sufficient attention to keeping the mouth as a whole clean; yet it is an exceedingly important part of the food-pipe, for anything harmful collecting there may be swallowed down, and may then be passed into the body.

Care of the Tongue

In another way we ought also to take care of the tongue. The tongue is the seat, or as we call it, the **organ**, of the sense of taste; and this sense, if we do not spoil it, is exceedingly useful to us in judging of our food. In fact, it is for this reason that it is placed at the beginning of the food-pipe, so that, if the nerves of the tongue send to the brain the message, Here is something nasty, the brain may send back the order, Do not swallow it; and so we can put it out of our mouths. Of course when we are ill, we sometimes have to take nasty medicine but that is exceptional. If our bodies are healthy, and the food-pipe and the nerves working as they are meant to do, then our tongue will tell us truly what is good for us and what is not. Thus you may have been eating an apple, biting pieces from it without looking, and so have taken into your mouth a part which was brown and rotten. Did not your tongue instantly tell you that that part was nasty and bitter—not fit to be swallowed; and did not you instantly prevent yourself from swallowing it?

I think the tongue might be called "gate-keeper" as well as the pylorus muscle—do not you? It has to keep the gate of the throat, as the pylorus keeps the gate of the small intestine.

How to Spoil One's Sense of Taste

Unfortunately a great many people spoil their sense of taste, so that it is of little use to them. This is a serious matter, for they are thus led to eat and drink many harmful things. Our sense of taste, if properly educated, likes plain and simple food for the most part—bread, fruit, milk, meat, sugar, and so on. But we often force it to accept foods that are highly seasoned, having different strong-tasting substances mixed with them. The nerves of taste, after rebelling for a little while, get used, as we say, to these new things—even grow to be pleased with them; and then their messages to the brain no longer tell whether the food is good or not. Once accustomed to highly-seasoned food, the tongue can hardly taste the simple, wholesome things which before seemed pleasant.

One of the substances with which people spoil their sense of taste is strong, over-drawn tea. Another, yet more injurious, is alcohol. When we first take it our tongue gives us faithful warning: This is not good; this must be spat out. I do not think a single person tasting beer, wine, or spirits for the first time ever thinks them pleasant to drink. He probably makes quite a fearful grimace because they taste so disagreeable. But many persons, as we know, neglect that faithful warning. They force the tongue into a habit of liking alcohol, and by doing so they make the tongue incapable of tasting aright. Yet another substance which spoils the taste is tobacco. No one whose tongue is being constantly exposed to the juice or the fumes of tobacco can taste properly, as he was meant to do.

So in order to keep our sense of taste healthful, we must eat good and plainly prepared food, and we must not use either strong tea, alcohol, or tobacco.

But perhaps you will say it does not matter so much about the tongue, provided the rest of the food-pipe gets on all right. Yes, but the rest of the food-pipe gets on very badly if you have a poor gate-keeper, who lets things through anyhow. Some of the foods which you may have grown to think pleasant give the stomach a great deal of trouble, and perhaps, after all, supply very little nourishment. Others are actually hurtful, some in one way and some in another; whilst the alcohol, which is not a food at all, and is of no use to a person in ordinary health, interferes with the work of digestion, and does serious harm in several ways. We shall see this later on when we come to consider what we should take and what we should avoid in eating and drinking.

Getting Rid of Waste Matter

Another point I must mention about the care of the food-pipe is the necessity for getting rid of the rubbish regularly. What would you think of a person who should collect into a bag all the old cabbage stalks, potato skins, scraps of gristle, and bones remaining from his meals, and should carry this bagful constantly about with him—at table, in bed, going about his business—everywhere. You would say he was a mad person, and his ways disgusting, and you would be quite right. And yet we are sometimes apt, through carelessness, to act in the very same manner, and carry about with us rubbish which ought to be quickly got rid of.

If the waste matter from our food is allowed to collect day by day in the large intestine, it greatly hinders the working of the food-pipe. Moreover, it soon begins to decompose, that is, to break up into different separate substances, and some of it then passes into the blood, where it acts as a poison. Then one begins to feel heavy and uncomfortable, depressed and unable to enjoy either work or play; very likely one has a bad headache, and still more likely one is very cross. If this state of things continues, a number of troublesome ailments may be started, and the person who has not troubled to take care of his food-pipe in this particular respect, may be all his life hampered and weakened.

The lower part of the food-pipe should, as a rule, be emptied once every day and the best time for attending to this matter is in the morning, soon after breakfast. This is very much a question of habit; we can train our food-pipe to be ready to cast out the rubbish at a fixed time every day, just as by constant neglect we can get it into the very bad habit of keeping the rubbish in for a great length of time. At no time of life can a good habit be formed so well as in quite early childhood, and I should advise any of my girl readers who have the care of baby brothers and sisters to take thought to help them with regard to this. Animals here set us a very good example; any boy who has a dog knows how regular he is in taking a run for the purpose of attending to this need of his body.

There are three ways in which we can make the getting rid of the rubbish easy. First, as we have seen, by forming a good habit and not neglecting the warning given us by the nerves of the rectum. Secondly, by taking a proper amount of exercise—for if we sit still a great deal the muscles of the food-pipe are apt to get sluggish. And thirdly, by eating a sufficient quantity of vegetables and fruit, which, as we saw, are a help to the muscles of the intestine in squeezing the food along. Baked apples and the use of salad oil with our vegetables are particularly good for this purpose.

It is a very great mistake to be often taking medicines to help us; for, by doing so, we weaken the action of the muscles, and accustom them to rely on outside assistance, instead of playing their own part, as they were meant to do.

Tight Clothing to be Avoided

There is just one more thing to say here about the care of the food-pipe. It ought never, in any part of it, to be compressed or squeezed together. Such squeezing hinders the action of the glands and muscles and also the flow of blood through the tiny blood-vessels which absorb the food. Hence no sensible person will wear tight clothes—all clothing should be loose. The stomach, the liver, and the pancreas are situated, as you may see in the diagrams, about the region of the waist, and so are very apt to be injured by stays and tight belts. I need hardly tell you that such injuries may become grave and even when that is not the case, a weakening of these very important organs must mean a weakening of the whole body.